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Indian Standard

ROLLING BEARINGS — STATIC LOAD RATINGS

(Second Revision)

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BUREAU OF INDIAN STANDARDS
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Indian Standard
ROLLING BEARINGS—STATIC LOAD RATINGS
(Second Revision)

NATIONAL FOREWORD

This Indian Standard (Second Revision), which is identical with ISO 76 : 1987 'Rolling bearings — Static load ratings', issued by the International Organization for Standardization (ISO), was adopted by the Bureau of Indian Standards on 4 November 1988 on the recommendation of the Rolling Bearings Sectional Committee (EDC 39) and approval of the Mechanical Engineering Division Council.

This standard was originally issued in 1966, and was revised in 1984 by adoption of ISO 76 : 1978. Consequent upon the revision of the ISO standard, this Indian Standard has also been revised to bring it in line with the latest ISO Standard.

In the adopted standard, certain terminology and conventions are not identical with those used in Indian Standards; attention is specially drawn to the following:

a) Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as decimal marker in the International Standard, while in Indian Standards, the current practice is to use point (.) as the decimal marker.

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0 Introduction

Permanent deformations appear in rolling elements and raceways of rolling bearings under static loads of moderate magnitude and increase gradually with increasing load.

It is often impractical to establish whether the deformations appearing in a bearing in a specific application are permissible by testing the bearing in that application. Other methods are therefore required to establish the suitability of the bearing selected.

Experience shows that a total permanent deformation of 0,000 1 of the rolling element diameter, at the centre of the most heavily loaded rolling element/raceway contact, can be tolerated in most bearing applications without the subsequent bearing operation being impaired. The basic static load rating is, therefore, given a magnitude such that approximately this deformation occurs when the static equivalent load is equal to the load rating.

Tests in different countries indicate that a load of the magnitude in question may be considered to correspond to a calculated contact stress of

- 4 600 MPa[1] for self-aligning ball bearings,
- 4 200 MPa for all other ball bearings, and
- 4 000 MPa for all roller bearings

at the centre of the most heavily loaded rolling element/raceway contact. The formulae and factors for the calculation of the basic static load ratings are based on these contact stresses.

The permissible static equivalent load may be smaller than, equal to or greater than the basic static load rating, depending on the requirements for smoothness of operation and friction, as well as on actual contact surface geometry. Bearing users without previous experience of these conditions should consult the bearing manufacturers.

1 Scope and field of application

This International Standard specifies methods of calculating the basic static load rating and the static equivalent load for rolling bearings within the size ranges shown in the relevant International Standards, manufactured from good quality hardened steel, in accordance with good manufacturing practice and basically of conventional design as regards the shape of rolling contact surfaces.

Calculations carried out in accordance with this International Standard do not yield satisfactory results for bearings in which, because of application conditions and/or because of internal design, there is a considerable truncation of the area of contact between the rolling elements and the ring raceways. The same limitation applies where application conditions cause deviations from a normal load distribution in the bearing, for example misalignment, preload or extra large clearance. Where there is reason to assume that such conditions prevail, the user should consult the bearing manufacturer for recommendations and evaluation of static equivalent load.

This International Standard is not applicable to designs where the rolling elements operate directly on a shaft or housing surface, unless that surface is equivalent in all respects to the bearing surface it replaces.

Double-row radial bearings and double-direction thrust bearings are, when referred to in this International Standard, presumed to be symmetrical.

2 Definitions

For the purposes of this International Standard, the following definitions apply.

2.1 static load: The load acting on a bearing when the speed of rotation of its rings in relation to each other is zero.

2.2 basic static radial load rating, C_{0r}: Static radial load which corresponds to a calculated contact stress at the centre of the most heavily loaded rolling element/raceway contact of

- 4 600 MPa for self-aligning ball bearings;
- 4 200 MPa for all other radial ball bearing types;
- 4 000 MPa for all radial roller bearings.

In the case of a single-row angular contact bearing, the radial load rating refers to the radial component of that load which causes a purely radial displacement of the bearing rings in relation to each other.

NOTE — For these contact stresses, a total permanent deformation of rolling element and raceway occurs which is approximately 0,000 1 of the rolling element diameter.

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[1] 1 MPa = 1 N/mm²

2.3 basic static axial load rating, C_{oa}: Static centric axial load which corresponds to a calculated contact stress at the centre of the most heavily loaded rolling element/raceway contact of

- 4 200 MPa for thrust ball bearings;
- 4 000 MPa for all thrust roller bearings.

NOTE — For these contact stresses, a total permanent deformation of rolling element and raceway occurs which is approximately 0,000 1 of the rolling element diameter.

2.4 static equivalent radial load, P_{or}: Static radial load which would cause the same contact stress at the centre of the most heavily loaded rolling element/raceway contact as that which occurs under the actual load conditions.

2.5 static equivalent axial load, P_{oa}: Static centric axial load which would cause the same contact stress at the centre of the most heavily loaded rolling element/raceway contact as that which occurs under the actual load conditions.

2.6 roller diameter (applicable in the calculation of load ratings), **D_{we}:** The diameter at the middle of the roller.

NOTE — For a tapered roller, this is equal to the mean value of the diameters at the theoretical sharp corners at the large end and the small end of the roller.

For an asymmetrical convex roller, this is an approximation for the diameter at the point of contact between the roller and the ribless raceway at zero load.

2.7 roller length (applicable in the calculation of load ratings), **L_{we}:** The theoretical maximum length of contact between a roller and that raceway where the contact is shortest.

NOTE — This is normally taken to be either the distance between the theoretical sharp corners of the roller minus the roller chamfers or the raceway width excluding the grinding undercuts, whichever is the smaller.

2.8 nominal contact angle, α: The angle between a plane perpendicular to the bearing axis and the nominal line of the resultant of the forces transmitted by a bearing ring to a rolling element.

2.9 Pitch diameter, D_{pw}

2.9.1 pitch diameter of a ball set: The diameter of the circle containing the centres of the balls in one row in a bearing.

2.9.2 pitch diameter of a roller set: The diameter of the circle intersecting the roller axes at the middle of the rollers in one row in a bearing.

3 Symbols

C_{or} = basic static radial load rating, in newtons

C_{oa} = basic static axial load rating, in newtons

D_{pw} = pitch diameter of a ball or roller set, in millimetres

D_w = ball diameter, in millimetres

D_{we} = roller diameter applicable in the calculation of load ratings, in millimetres

L_{we} = roller length applicable in the calculation of load ratings, in millimetres

F_r = bearing radial load = radial component of actual bearing load, in newtons

F_a = bearing axial load = axial component of actual bearing load, in newtons

P_{or} = static equivalent radial load, in newtons

P_{oa} = static equivalent axial load, in newtons

X_0 = radial load factor

Y_0 = axial load factor

Z = number of rolling elements in a single row bearing; number of rolling elements per row of a multi-row bearing with the same number of rolling elements per row

f_0 = factor which depends on the geometry of the bearing components and on the applicable stress level

i = number of rows of rolling elements in a bearing

α = nominal contact angle of a bearing, in degrees

4 Radial ball bearings

4.1 Basic static radial load rating

The basic static radial load rating for radial ball bearings is given by the formula

$$C_{or} = f_0 i Z D_w^2 \cos\alpha$$

where the values of f_0 are given in table 1.

The formula applies to bearings with a cross-sectional raceway groove radius not larger than 0,52 D_w in radial and angular contact groove ball bearing inner rings and 0,53 D_w in radial and angular contact groove ball bearing outer rings and self-aligning ball bearing inner rings.

The load-carrying ability of a bearing is not necessarily increased by the use of a smaller groove radius, but is reduced by the use of a groove radius larger than those indicated in the previous paragraph. In the latter case, a correspondingly reduced value of f_0 shall be used.

Table 1 — Values of factor f_0 for ball bearings[1]

$\frac{D_w \cos\alpha}{D_{pw}}$	Factor f_0		
	Radial ball bearings		Thrust ball bearings
	Radial and angular contact groove ball bearings	Self-aligning ball bearings	
0	14,7	1,9	61,6
0,01	14,9	2	60,8
0,02	15,1	2	59,9
0,03	15,3	2,1	59,1
0,04	15,5	2,1	58,3
0,05	15,7	2,1	57,5
0,06	15,9	2,2	56,7
0,07	16,1	2,2	55,9
0,08	16,3	2,3	55,1
0,09	16,5	2,3	54,3
0,1	16,4	2,4	53,5
0,11	16,1	2,4	52,7
0,12	15,9	2,4	51,9
0,13	15,6	2,5	51,2
0,14	15,4	2,5	50,4
0,15	15,2	2,6	49,6
0,16	14,9	2,6	48,8
0,17	14,7	2,7	48
0,18	14,4	2,7	47,3
0,19	14,2	2,8	46,5
0,2	14	2,8	45,7
0,21	13,7	2,8	45
0,22	13,5	2,9	44,2
0,23	13,2	2,9	43,5
0,24	13	3	42,7
0,25	12,8	3	41,9
0,26	12,5	3,1	41,2
0,27	12,3	3,1	40,5
0,28	12,1	3,2	39,7
0,29	11,8	3,2	39
0,3	11,6	3,3	38,2
0,31	11,4	3,3	37,5
0,32	11,2	3,4	36,8
0,33	10,9	3,4	36
0,34	10,7	3,5	35,3
0,35	10,5	3,5	34,6
0,36	10,3	3,6	
0,37	10	3,6	
0,38	9,8	3,7	
0,39	9,6	3,8	
0,4	9,4	3,8	

1) The table is based on the Hertz' point contact formula with a modulus of elasticity = 2,07 × 10^5 MPa and a Poisson's ratio of 0,3. It is assumed that the load distribution for radial ball bearings results in a maximum ball load of $5 \frac{F_r}{Z \cos\alpha}$, and, for thrust ball bearings, $\frac{F_a}{Z \sin\alpha}$. Values of f_0 for intermediate values of $\frac{D_w \cos\alpha}{D_{pw}}$ are obtained by linear interpolation.

4.1.1 Bearing combinations

4.1.1.1 The basic static radial load rating for two similar single-row radial or angular contact ball bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in "back-to-back" or "face-to-face" arrangement is twice the rating of one single row bearing.

4.1.1.2 The basic static radial load rating for two or more similar single-row radial or angular contact ball bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, properly manufactured and mounted for equal load distribution, is the number of bearings times the rating of one single-row bearing.

4.2 Static equivalent radial load

The static equivalent radial load for radial ball bearings is the greater of the two values given by the formulae

$$P_{or} = X_0 F_r + Y_0 F_a$$

$$P_{or} = F_r$$

where the values of factors X_0 and Y_0 are given in table 2.

Values of Y_0 for intermediate contact angles are obtained by linear interpolation.

Table 2 — Values for factors X_0 and Y_0 for radial ball bearings

Bearing type		Single row bearings		Double row bearings	
		X_0	Y_0	X_0	Y_0
Radial contact groove ball bearings[1]		0,6	0,5	0,6	0,5
Angular contact groove ball bearings, α =	15°	0,5	0,46	1	0,92
	20°	0,5	0,42	1	0,84
	25°	0,5	0,38	1	0,76
	30°	0,5	0,33	1	0,66
	35°	0,5	0,29	1	0,58
	40°	0,5	0,26	1	0,52
	45°	0,5	0,22	1	0,44
Self-aligning ball bearings, $\alpha \neq 0°$		0,5	0,22 $\cot\alpha$	1	0,44 $\cot\alpha$

1) Permissible maximum value of F_a/C_{or} depends on bearing design (internal clearance and raceway groove depth).

4.2.1 Bearing combinations

4.2.1.1 When calculating the static equivalent radial load for two similar single-row radial or angular contact ball bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in "back-to-back" or "face-to-face" arrangement, the X_0 and Y_0 values for a double-row bearing and the F_r and F_a values for the total loads on the arrangement shall be used.

4.2.1.2 When calculating the static equivalent radial load for two or more similar single-row radial or angular contact ball bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, the X_0 and Y_0 values for a single-row bearing and the F_r and F_a values for the total loads on the arrangement shall be used.

5 Thrust ball bearings

5.1 Basic static axial load rating

The basic static axial load rating for single- or double-direction thrust ball bearings is given by the formula

$$C_{oa} = f_0 Z D_w^2 \sin\alpha$$

where the values of f_0 are given in table 1 and Z is the number of balls carrying load in one direction.

The formula applies to bearings with a cross-sectional raceway groove radius not larger than 0,54 D_w.

The load-carrying ability of a bearing is not necessarily increased by the use of a smaller groove radius, but is reduced by the use of a larger groove radius. In the latter case, a correspondingly reduced value of f_0 shall be used.

5.2 Static equivalent axial load

The static equivalent axial load for thrust ball bearings with $\alpha \neq 90°$ is given by the formula

$$P_{oa} = 2{,}3\, F_r \tan\alpha + F_a$$

This formula is valid for all ratios of radial load to axial load in the case of double-direction bearings. For single-direction bearings, it is valid where $F_r/F_a < 0{,}44 \cot\alpha$ and gives satisfactory but less conservative values of P_{oa} for F_r/F_a up to 0,67 $\cot\alpha$.

Thrust ball bearings with $\alpha = 90°$ can support axial loads only. The static equivalent axial load for this type of bearing is given by the formula

$$P_{oa} = F_a$$

6 Radial roller bearings

6.1 Basic static radial load rating

The basic static radial load rating for radial roller bearings is given by the formula

$$C_{or} = 44 \left(1 - \frac{D_{we}\cos\alpha}{D_{pw}}\right) i Z L_{we} D_{we} \cos\alpha$$

6.1.1 Bearing combinations

6.1.1.1 The basic static radial load rating for two similar single-row roller bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in "back-to-back" or "face-to-face" arrangement is twice the rating of one single-row bearing.

6.1.1.2 The basic static radial load rating for two or more similar single-row roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, properly manufactured and mounted for equal load distribution, is the number of bearings times the rating of one single-row bearing.

6.2 Static equivalent radial load

The static equivalent radial load for roller bearings with $\alpha \neq 0°$ is the greater of the two values given by the formulae

$$P_{or} = X_0 F_r + Y_0 F_a$$

$$P_{or} = F_r$$

where the values of factors X_0 and Y_0 are given in table 3.

Table 3 — Values for factors X_0 and Y_0 for radial roller bearings with $\alpha \neq 0°$

Bearing type	X_0	Y_0
Single-row	0,5	$0{,}22 \cot\alpha$
Double-row	1	$0{,}44 \cot\alpha$

The static equivalent radial load for radial roller bearings with $\alpha = 0°$, and subjected to radial load only, is given by the formula

$$P_{or} = F_r$$

NOTE — The ability of radial roller bearings with $\alpha = 0°$ to support axial loads varies considerably with bearing design and execution. The bearing user should therefore consult the bearing manufacturer for recommendations regarding the evaluation of equivalent load in cases where bearings with $\alpha = 0°$ are subjected to axial load.

6.2.1 Bearing combinations

6.2.1.1 When calculating the static equivalent radial load for two similar single-row angular contact roller bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in "back-to-back" or "face-to-face" arrangement, the X_0 and Y_0 values for a double-row bearing and the F_r and F_a for the total loads on the arrangement shall be used.

6.2.1.2 When calculating the static equivalent radial load for two or more similar single-row angular contact roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, the X_0 and Y_0 values for a single-row bearing and the F_r and F_a values for the total loads on the arrangement shall be used.

7 Thrust roller bearings

7.1 Basic static axial load rating

The basic static axial load rating for single- and double-direction thrust roller bearings is given by the formula

$$C_{oa} = 220\left(1 - \frac{D_{we}\cos\alpha}{D_{pw}}\right) Z L_{we} D_{we} \sin\alpha$$

where Z is the number of rollers carrying load in one direction.

In cases where rollers have different lengths, ZL_{we} is taken as the sum of the lengths, defined in 2.7, of all the rollers carrying load in one direction.

7.1.1 Bearing combinations

The basic static axial load rating for two or more similar single-direction thrust roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, properly manufactured and mounted for equal load distribution, is the number of bearings times the rating of one single-direction bearing.

7.2 Static equivalent axial load

The static equivalent axial load for thrust roller bearings with $\alpha \neq 90°$ is given by the formula

$$P_{oa} = 2{,}3\,F_r \tan\alpha + F_a$$

This formula is valid for all ratios of radial load to axial load in the case of double-direction bearings. For single-direction bearings, it is valid where $F_r/F_a < 0{,}44 \cot\alpha$ and gives satisfactory but less conservative values of P_{oa} for F_r/F_a up to $0{,}67 \cot\alpha$.

Thrust roller bearings with $\alpha = 90°$ can support axial loads only. The static equivalent axial load for this type of bearing is given by the formula

$$P_{oa} = F_a$$

7.2.1 Bearing combinations

When calculating the static equivalent axial load for two or more similar thrust roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, the F_r and F_a values for the total loads acting on the arrangement shall be used.

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